

ELECTROWEAK AND QCD RESULTS FROM DØ

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We present some of the results in the areas of QCD and Electroweak physics for Run II of the DØ experiment at the Fermilab Tevatron. QCD results include dijet angular decorrelations and inclusive jet and dijet cross sections. Electroweak results include the decay of Z bosons to tau pairs and several results on gauge boson pairs. No deviations from the Standard Model have been observed.

1. Introduction

The DØ experiment is a multi-purpose collider detector located at the Fermilab Tevatron proton-antiproton collider. After undergoing a substantial upgrade, the experiment is now taking data at $\sqrt{s} = 1.96$ TeV. There are many new results based on this Run II data in the areas of Quantum Chromodynamics (QCD) and Electroweak physics.

2. QCD Results

A study has been performed of the angular correlations in jets produced in the DØ detector ¹. At leading order in QCD, jets are expected to be produced back-to-back in azimuth (ϕ). One would then expect that the difference in azimuthal angle between two jets is $\Delta\phi = \pi$. However, higher order effects, such as additional soft radiation in the event, will cause this angular difference to be less than π . The distribution of $\Delta\phi$ is sensitive to higher order effects. Additionally, this measurement does not rely on measuring the energy of the jet and hence does not suffer from energy scale systematic uncertainties. Figure 1 shows the $\Delta\phi$ distribution for jets in four different transverse momentum bins compared to the predictions from Monte Carlo generators.

The inclusive jet cross section and the dijet cross section have also been measured. These distributions are sensitive to both the strong coupling

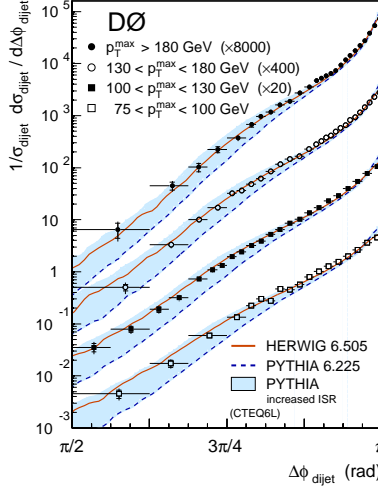


Figure 1. The $\Delta\phi$ distributions in different p_T^{max} ranges. Results from HERWIG and PYTHIA are overlaid on the data. HERWIG results agree with the data, but PYTHIA results require modifications to the default parameters.

constant and to the parton density functions. Furthermore, many new physics models predict enhancements in the dijet mass cross section at large values of invariant mass. Figure 2 shows both the inclusive jet cross section and the dijet cross section distributions. These distributions are consistent with the next-to-leading order perturbative QCD theoretical predictions.

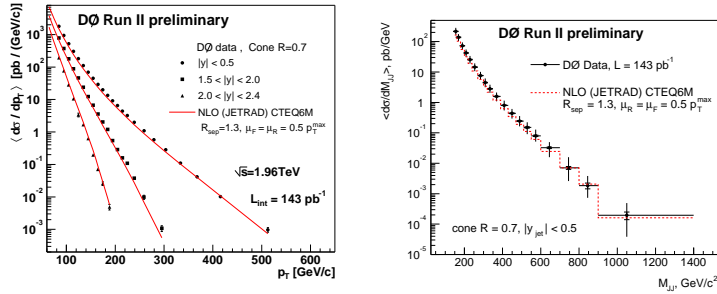


Figure 2. The left plot shows the inclusive jet cross section, measured in different ranges of jet rapidity (with statistical errors only). NLO pQCD calculations are overlaid on the data. The right plot shows the dijet cross section, measured at central rapidities. NLO pQCD calculations are overlaid on the data.

3. Electroweak Results

DØ has performed a measurement of the cross section times branching fraction for Z bosons decaying to tau pairs ². This measurement is a verification of the tau identification abilities for the experiment as well as a test of lepton universality. Furthermore, some physics models predict final states that would result in an excess of tau pair events over Standard Model predictions.

The analysis requires one tau to decay as a muon. The second tau is identified using a neural network that has been trained using the different tau decay topologies. 2008 candidate events are selected in 226 pb^{-1} of data. Approximately 55% of these events are estimated to be background events. This results in a measurement of $\sigma \cdot \text{Br}(Z \rightarrow \tau\tau) = 237 \pm 15_{\text{stat}} \pm 18_{\text{sys}} \pm 15_{\text{lum}}$ pb. This is consistent with the Standard Model prediction of 242 ± 9 pb.

DØ also has a variety of results on diboson production. At the Tevatron, pairs of gauge bosons can be produced through t or u channel quark exchange, or can be produced through an s -channel triple gauge boson vertex. The strength of these triple gauge boson vertices is an important test of the Standard Model. Diboson signatures are also important backgrounds for Higgs and new physics searches.

The cross section for the production of $p\bar{p} \rightarrow W\gamma + X$ has been measured. This analysis requires the W boson to decay to either an electron or a muon and a neutrino. The photon is identified by its signature in the calorimeter and the absence of a matching track in the central tracking system. In the electron channel, 112 events are selected in 162 pb^{-1} of data. In the muon channel, 161 events are identified in 134 pb^{-1} of data. In both channels, the background is estimated to be approximately half the number of events in data. The combination of both channels results in a cross section measurement for $W\gamma X \rightarrow l\nu X$ of $14.8 \pm 1.6_{\text{stat}} \pm 1.0_{\text{sys}} \pm 1.0_{\text{lum}}$ pb. This is in agreement with the Standard Model prediction of 16.0 ± 0.4 pb.

A measurement of the cross section times branching fraction has been performed for events with a photon and a Z boson, with the Z boson decaying to electron or muon pairs ³. In the $ee\gamma$ channel, 33 data events are present in 177 pb^{-1} of data, with an estimated background of 4.7 ± 0.7 events. In the $\mu\mu\gamma$ channel, 68 data events are present in 144 pb^{-1} of data, with an estimated background of 10.1 ± 1.3 events. Figure 3 shows the three body invariant mass versus two body invariant mass for the candidate events. The combined cross section times branching fraction for both

channels is $3.90 \pm 0.51_{stat+sys} \pm 0.25_{lum}$ pb, which is in good agreement with the expected value of 4.3 pb.

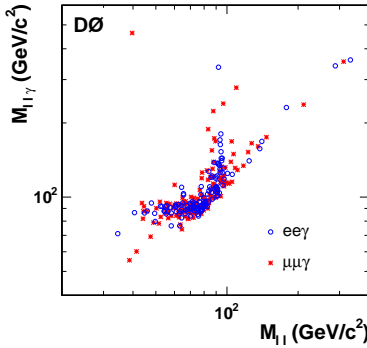


Figure 3. Invariant mass of the dilepton system vs. invariant mass of dilepton and a photon candidate.

A search for pairs of W bosons has also been performed⁴. This analysis selects events with two opposite sign leptons (electrons or muons) and missing energy. A total of 25 events are selected in between 224 and 252 pb^{-1} of data (depending on the channel). The background has been estimated to be $8.1 \pm 0.6_{stat} \pm 0.6_{sys} \pm 0.5_{lum}$. The data represents a 5.2σ excess over the background prediction.

A search for WZ events has been performed by selecting events that have three leptons (electrons or muons) and missing energy⁵. The missing transverse energy versus dilepton invariant mass distribution is shown in Figure 4. A total of three candidate events are observed in data in approximately 300 pb^{-1} of data. There are 2.04 ± 0.13 expected signal events and 0.71 ± 0.08 expected background events. A 95% confidence level limit on the cross section has been set at 13.3 pb.

Limits have also been set on anomalous $WW\gamma$ and WWZ couplings. These couplings can be parameterized in an effective Lagrangian, with a scale factor Λ . Figure 5 shows the limits set on the anomalous coupling parameters. All of these anomalous coupling limit parameters are predicted to be zero in the Standard Model.

References

1. V.M. Abazov, *et al.* (The D0 Collaboration), FERMILAB-PUB-04/217-E, submitted to Phys. Rev. Lett.

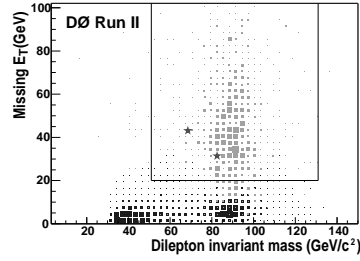


Figure 4. Dilepton invariant mass vs. missing transverse energy for expected $WZ \rightarrow \mu\mu\mu\nu$ events (green or light grey) and for expected $Z + \text{jet}$ background events (blue or dark grey). The central box shows the event selection criteria.

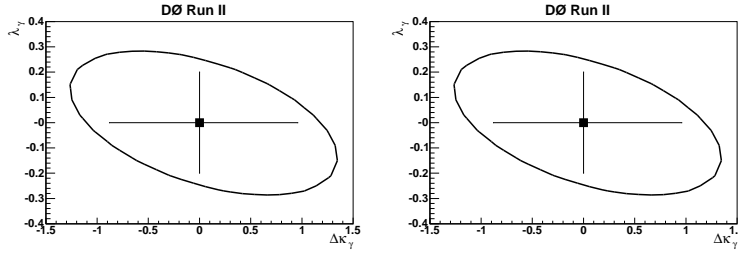


Figure 5. Left plot shows the limits on the $WW\gamma$ coupling parameters $\Delta\kappa_\gamma$ and λ_γ . The point indicates the SM value with the error bars showing the 95% CL intervals in one dimension. the ellipse represents the two-dimensional 95% CL exclusion contour. The right plot shows two-dimensional coupling limits (inner contour) on λ_z vs. Δg_1^z at 95% C.L. for $\Lambda = 1.5$ TeV. The outer contour is the limit from S -matrix unitarity.

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